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B1 ~~Description~~

Method and radio communications system for data transmission via a radio interface between a base station and a subscriber station

Ins B2

The invention relates to a method and a radio communications system for data transmission via a radio interface between a base station and a subscriber station, in particular via broadband radio interfaces, which use a CDMA subscriber separation method and at the same time provide a number of services per connection.

Ins B3

In radio communications systems, messages (for example voice, video information or other data) are transmitted via a radio interface by using electromagnetic waves. The radio interface relates to a connection between a base station and subscriber stations, in which case the subscriber stations may be mobile stations or stationary radio stations. The electromagnetic waves are in this case transmitted at carrier frequencies which are in the frequency band intended for the respective system. Frequencies in the frequency band around 2000 MHz have been provided for future radio communications systems, for example the UMTS (Universal Mobile Telecommunication System), or other 3rd Generation systems.

Broadband (B = 5 MHz) radio interfaces are provided for third generation mobile radio, which use a CDMA subscriber separation method (CDMA code division multiple access) to distinguish between different transmission channels, and can provide a number of services per connection at the same time. In this case, one problem that arises is how the data for different services can be time-division multiplexed, that is to say entered in a frame, for one connection. The transmission

capacity of the radio interface must be utilized as well as possible, taking account of a wide dynamic range in the variance of the data rates for the individual services. To this end, the ETSI SMG2/UMTS L23 expert group, Tdoc SMG2 UMTS-L23 152/98, September 1-4, 1998, Helsinki, Finland, in particular on pages 11-15, has proposed that a number of transport formats be specified and that permissible combinations of these transport formats for setting up connections be defined for each connection. It is possible to change between the combinations depending on the dynamic range of the bit rates of the individual services, with such a change being signaled on a frame basis.

Ins B4

The frame-based adaptation of the transport format allows the dynamic range of the data traffic to be coped with with little signaling complexity. However, the signaling complexity for setting up a connection is high, and the previously defined combinations limit the variation options. Particularly in the case of data services where the traffic is in the form of bursts, this has a disadvantageous effect on the mean channel capacity, when high transmission rates sudden follow lengthy pauses. Furthermore, a process of selecting one of the combinations has not yet been solved satisfactorily.

In consequence, the invention is based on the object of specifying a method and a radio communications system, in which the coding complexity for the format information for simultaneous transmission of data for a number of services is low, and there are no relationships between the services to limit the combination options. This object is achieved by the method having the features of claim 1 and by the radio communications system having the features of claim 12. Advantageous developments of the invention can be found in the dependent claims.

According to the invention, data from a number of services can be transmitted simultaneously between the base station and the subscriber station. In this case, a service-specific block size which can be defined individually for each service is used as the smallest transmission unit. A number of blocks to be transmitted for each service occur per frame, depending on the amount of data to be transmitted at that time. This number of blocks for each service is signaled for each frame.

The arrangement of the blocks for the services in the frame is obtained from the number of services and the number of blocks per service, in accordance with predetermined coding. This mapping rule, which is referred to as coding in the following text, is unambiguous, and the receiver can thus reconstruct it without any further signaling. The format information is thus obtained unambiguously from the transmitted amount of information.

The data are entered in the frame in accordance with the predetermined coding, a frame with blocks for a number of services is transmitted via the radio interface and, at the receiving end, the data are read from the frame in accordance with the predetermined coding and the signaled number of blocks per service.

The transmission format, in the form of the block size and the number of blocks, is defined as a function of the service without any relationships between the services and can be individually and dynamically matched to the data rate of each individual service. This unlimited dynamic range allows the data to be mapped completely onto the transmission channels even if the data rates for the individual services fluctuate severely. It thus becomes feasible to transmit at the maximum possible data rate, thus allowing better utilization of the radio resources available at any given time.

The required dynamic range can be chosen freely for each of the services. It is thus possible to allow a wide variation in the allocated resources for certain services whose data rate fluctuates very rapidly. Other services can be allocated a fixed data rate, or a data rate which varies only slightly. The coding complexity for the format information can be defined on a service-specific basis, and can thus be matched very flexibly to the required dynamic range. Overall, it is no higher than with the previous method since, in particular, the signaling complexity for setting up a connection is reduced. The complex process of determining the optimum combination of transmission formats is superfluous.

According to advantageous developments of the invention, the predetermined coding indicates the sequence of the blocks, the number of transmission channels being used at the same time and/or the spread factors used in the transmission channels. These details thus do not need to be signaled but are obtained unambiguously from the block size and the number of blocks per service. This reduces the signaling complexity.

The number of blocks per service is signaled either as an absolute statement in each frame, or relative to the statements in the preceding frame. Absolute coding is more suitable for services with data rates which are low but are known a priori. The data rates can be switched very suddenly, and there is no need for initial transmission of the number of blocks. The relative coding allows very accurate matching of the data rate to the actual service data stream, and it is possible to allocate any desired number of blocks between 0 and the maximum value for the data rate.

The number of blocks per service is advantageously varied from frame to frame in steps of different size.

This means that, with absolute coding, it is possible to switch very quickly between widely differing data rates and, with relative coding, the rate of adaptation of the data rate can be varied. Allocation of different numbers of steps for each service makes it possible to take account of the specific dynamic range of data sources. Relative and absolute coding can also be combined with one another. The block size can advantageously be one bit, as a result of which the signaled number of blocks reflects the amount of information.

The predetermined coding is defined on a system-wide basis or is defined when setting up a connection between the base station and the subscriber station. System-wide definition minimizes the signaling complexity, while signaling when setting up a connection provides additional degrees of freedom.

According to one advantageous development of the invention, predetermined coding minimizes the number of transmission channels per connection between the base station and the subscriber station. This is achieved by appropriate choice of the spread factors.

Ins B5

Exemplary embodiments of the invention will be explained in more detail with reference to the appended drawings, in which:

Figure 1 shows a schematic illustration of a radio communications system,

Figure 2 shows a schematic illustration of requirements for three services which can be transmitted simultaneously,

Figure 3 shows a flowchart for data transmission, and

Figure 4 shows how the services are mapped onto the transmission channels at different times.

Ins B6

The mobile radio system illustrated in Figure 1, as an example of a radio communications system, comprises

a large number of mobile switching centers MSC which are networked with one another and/or provide access to a landline network PSTN. Furthermore, these mobile switching centers MSC are each connected to at least one device RNM for allocating radio resources. Each of these devices RNM in turn allows a connection to be set up to at least one base station BS. Such a base station BS can use a radio interface to set up a connection to subscriber stations, for example mobile stations MS or any other types of mobile or stationary terminals. At least one radio cell is formed by each base station BS.

Figure 1 shows a connection V for simultaneous transmission of user information for a number of service S1, S2, S3 between a base station BS and a mobile station MS.

An operation and maintenance center OMC provides monitoring and maintenance functions for the mobile radio system, or for parts of it. The functionality of this structure can be transferred to other radio communication systems in which the invention can be used, in particular for subscriber access networks using wire-free subscriber access.

Unidirectional data transmission from the base station BS to the mobile station MS will be explained in more detail in the following text, and the means used for this purpose will be described. The base station BS in this case represents the transmission end, and the mobile station MS the receiving end. Both ends contain the appropriate components for bidirectional data transmission. The transmission end comprises signaling means SA for producing signaling information, coding means KM for entering data for the services S1, S2, S3 in a frame, and transmission means TX for transmitting frames to the receiving end. At the receiving end, reception

means RX are provided for receiving the frames, decoding means DKM for reading the data from the frame, and signaling means SA for evaluating the signaling information. The coding, decoding and signaling means KM, DKM and SA are in the form of digital signal processing processors, while the transmission and reception means TX, RX are also formed from radio-frequency components.

Within the connection V, the data d1, d2, d3 for three different services S1, S2, S3 are transmitted simultaneously as shown in Figure 2. These three services S1, S2, S3 differ to a major extent in the possible values and the dynamic range of the data rate. The block sizes B and absolute or relative coding were chosen accordingly.

According to Figure 3, once a connection has been set up, which defines the services S1, S2, S3 to be supported and the connection context, the sequence of the services S1, S2, S3 in the transmission is defined, for example on the basis of prioritization, the delay times to be complied with and the filling of a queue. A service-specific block size B is defined in the same way. Each service i may have its own block size Bi, which defines the granularity. The data are therefore always transmitted in multiples of this block size Bi. In the extreme, the block size Bi is equal to one bit, so that the number of blocks to be transmitted coincides with the amount of data in bits.

Before each frame fr is transmitted, the number of blocks per service S1, S2, S3 contained in the next frame fr is then defined on the basis of the amount of data occurring from the data source. The maximum permissible delay for each service S1, S2, S3 and the prioritization are also significant factors in this case.

Before writing the data to the frame fr, the data for the individual services S1, S2, S3 are subjected to

individual channel-coding and to a so-called balancing algorithm in order that each service S1, S2, S3 is given its individual quality of service (QoS) within the signal which is to be transmitted and which results in a standard signal-to-noise ratio. After this, each service S1, S2, S3 has a specific gross data rate Ri, which results, for example with a frame duration of 10 ms, in the number Ni of bits to be transmitted in total per frame being:

$$Ni = 10(Ri/kbps) \text{ bits.}$$

Then, as an option, the data are encrypted over a number of frames. The encryption parameters can once again be set individually for each service S1, S2, S3. The greater the maximum permissible delay time for the service S1, S2, S3, the deeper the encryption depth that can be chosen.

The total number of bits to be transmitted in a frame fr is given by the sum Nreq of the bits from all the services S1, S2, S3.

On the assumption of the boundary condition that as few transmission channels as possible are intended to be used per connection V, the sum Nreq allows the number of required transmission channels m and the associated spread factors SFj, where j=1..m, to be derived unambiguously, since, provided m>1, all

channels except one have the minimum spread factor SF=4:

$$m = \left[\frac{Nreq}{bit/fr} \cdot \frac{1}{10240} \right]$$ where [] is a rounding operator

$$SFm = Min\left(\left[\frac{40960}{\frac{Nreq}{bit/fr} - (m-1)\cdot 10440} \right], 256 \right)$$

where [] is a rounding operator for the next power of two SF = 4 for m>1 and j=1..m-1.

The constants 10240 and 40960 are related to the maximum number of bits or chips per frame with the minimum spread factor SF=4, assuming a CDMA transmission scheme in accordance with ETSI STC SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1 221/98, dated August 25, 1998.

This coding is known at the transmission and receiving ends and can be defined on a system-wide basis, or can be signaled when setting up a connection. Alternatively, other boundary conditions may also be specified, which lead to different coding (number m of transmission channels, the spread factors SF used and the sequence of blocks within the frame fr) than the mapping scheme for the data d1, d2, d3 to the frame fr. At the transmission and receiving ends, the coding need be an unambiguous function only of the transmitted amount of information, in the form of the number of blocks K, the number of bits K, or on the basis of blind detection during the detection process.

This predetermined coding is used when writing data to the frame fr. Only the number K of blocks per service S1, S2, S3 need be signaled from frame fr to frame fr.

The number of blocks K can be signaled absolutely or relative to the preceding frame.

Absolute:

The service i is allocated a set with z different multiples of the block size B. lb(z) bits are required to code the element used in the set.

For example if z=4: Ki1=7, Ki2=9, Ki3=10, Ki4=12. The number of blocks which can be transmitted in a frame for this service is thus either 7, 9, 10 or 12.

Relative:

The number of blocks Ki for the service i in the present frame fr is stated relative to the number of blocks in the preceding frame fr. The service is allocated a total number of z steps, which need not necessarily be the same size, in which the number of blocks can increase or decrease. lb(z) bits are also required for coding in this case. For example, if z=5: $\Delta Ki1 = -2$, $\Delta Ki2 = -1$, $\Delta Ki3 = -0$, $\Delta Ki4 = 2$, $\Delta Ki5 = 4$

Depending on the signaling, the number of blocks Ki may be reduced by two blocks or one, or may be increased by two or four blocks. However, it may also remain the same.

After transmission, which takes place via the radio interface using a CDMA subscriber separation method according to ETSI STC SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1 221/98, dated August 25, 1998, the data can be read from the frame at the receiving end with the aid of the coding and the signaled number of blocks K. The transmission is continued, with the capability to adapt the number of blocks K continuously, until the connection is cleared.

For the three services S1, S2, S3 shown in Figure 2, transmission in the illustrated formats is possible at

times t1 and t2 in the two instantaneous illustrations shown in Figure 4.

At the time t1, five blocks can be transmitted for the first service S1, 16 blocks for the second service S2, and one block for the third service S3. The data rates thus correspond to 2000 bits per frame fr of 10 ms (200 kbps), 9600 bits per frame fr and 800 bits per frame fr, respectively. Based on the coding rule described above, this results in m=2, with a minimum spread factor SF=4 being used for spreading the data in the first transmission channel, and the spread factor SF=16 being used to spread the data in the second transmission channel. The total available transmission capacity is thus 12 800 bits per frame fr.

The timeslots are ignored when filling the frames fr. 3/4 of the last block is thus transmitted in the first transmission channel and the last 1/4 of this block is transmitted, with a correspondingly greater spread, in the second transmission channel. Part of the second transmission channel is not required and remains free in the downlink direction (from the base station BS to the mobile station MS), that is to say the transmitter is switched off. In the uplink direction, but optionally also in the downlink direction, an equalization method is used with data rate adaptation by means of data repetition or puncturing, and the transmitter is not switched off.

The total number of bits to be transmitted per frame at the time t2 is only 9000, so that one transmission channel with the spread factor SF=4 is sufficient. One block for the first service S1, 13 blocks for the second service S2 and one block for the third service S3 are transmitted in that one transmission channel.